SnoSCAT

Snoqualmie Science Coordination and Advisory Team

A collaborative roundtable focused on stream temperature in the Snoqualmie Watershed

Snoqualmie River Basin
Temperature
Total Maximum Daily Load

Water Quality Improvement Report and Implementation Plan

June 2011
Publication No. 11-10-041

DEPARTMENT OF ECOLOGY
State of Washington

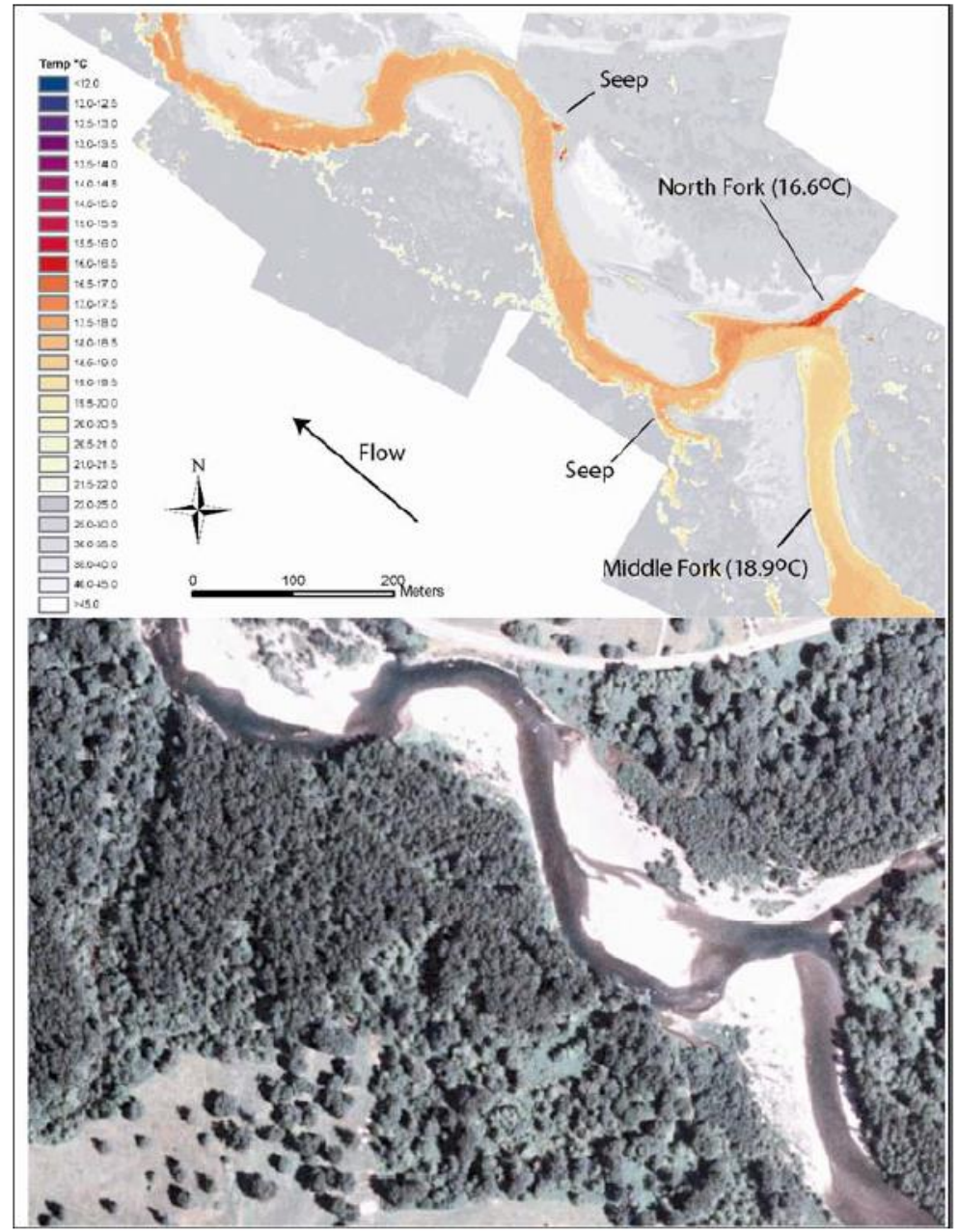
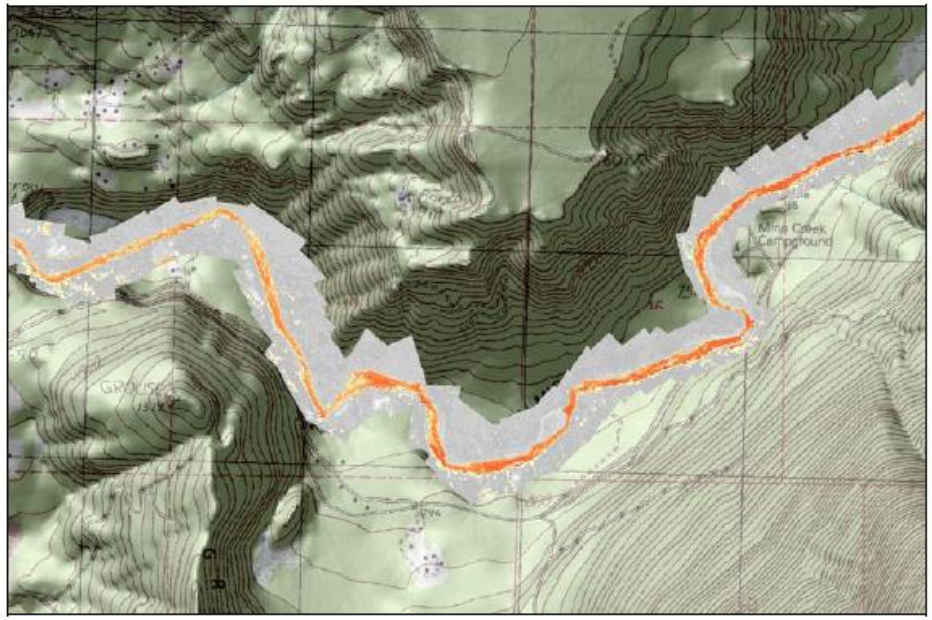


Figure 64. Sample image; thermal infrared (top) and true color (bottom) showing the confluence of the North Fork and Middle Fork Snoqualmie River (Watershed Sciences, 2007).

Airborne Thermal Infrared Remote Sensing
Snoqualmie River Basin, WA



Submitted to:

TETRA TECH

John Craig
Tetra Tech, Inc.
1230 Columbia Street, Suite 250
San Diego, CA 92101

Contract #: 68-C-02 108

Department of Ecology

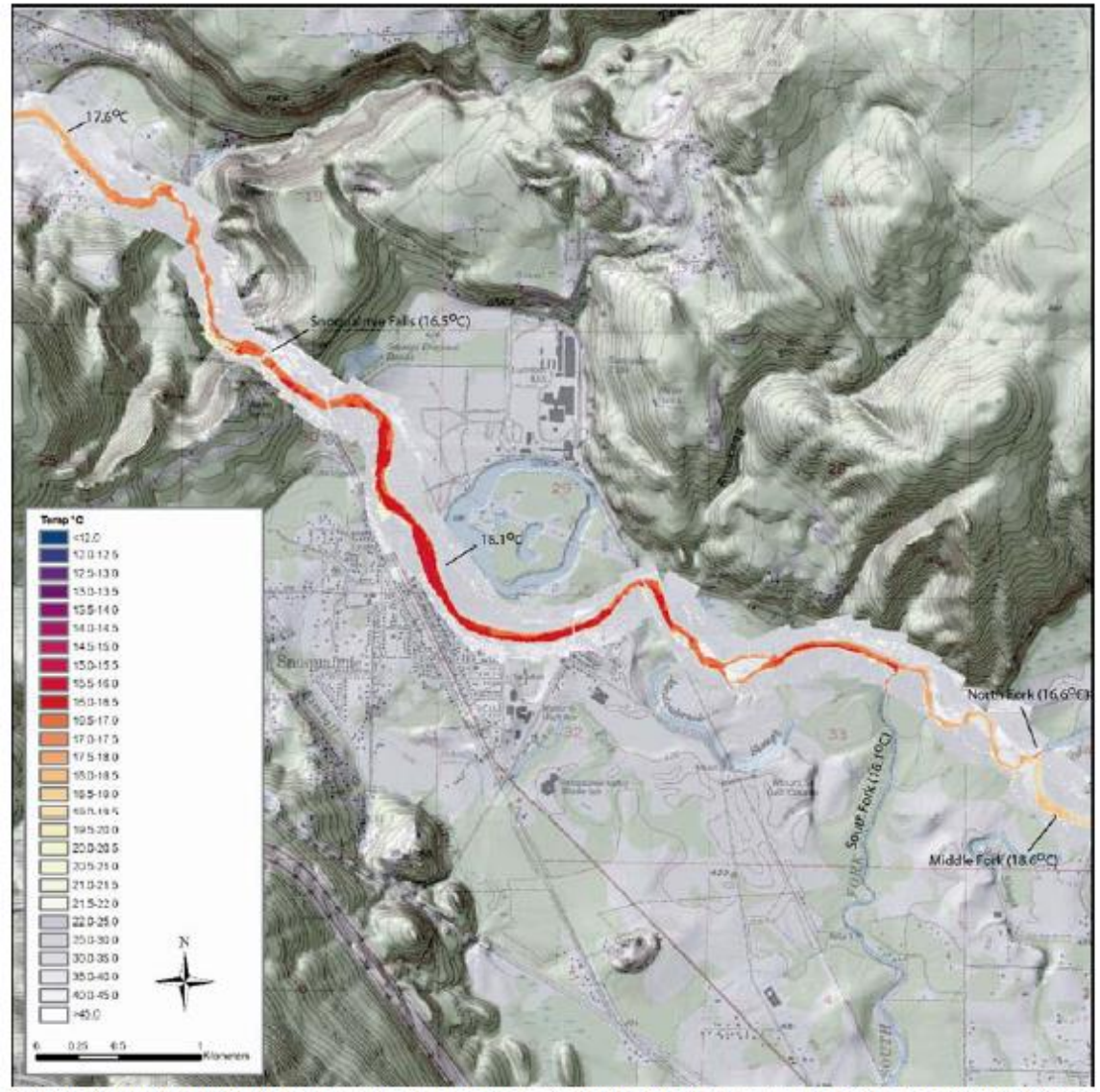
Washington Department of Ecology
Environmental Assessment Program
P.O. Box 47710
Olympia, WA 98504

Submitted by:

Watershed Sciences

Watershed Sciences, Inc.
111 NW 2nd Street, Unit 1
Corvallis, OR 97330

Survey Date: August 13, 2006
Report Date: March 12, 2007



Sample Image Snoqualmie River – The image above shows the TIR image mosaic of the Snoqualmie River from mile 37.8 to the Middle Fork Confluence (mile 43.3) plotted over the 1:24K USGS topographic maps. Radiant temperatures are labeled to illustrate the longitudinal temperature pattern through this reach. The North Fork and South Fork Snoqualmie River both have a cooling influence on the river. However, the river does not reach a local minimum of 16.1°C until river mile 40.4. The continued cooling combined with the valley morphology suggests some sub-surface influence between the South Fork (mile 42.6) and the town of Snoqualmie (mile 40.4). Stream temperatures increased slightly (~0.5°C) to Snoqualmie Falls, before exhibiting steady and consistent downstream warming.

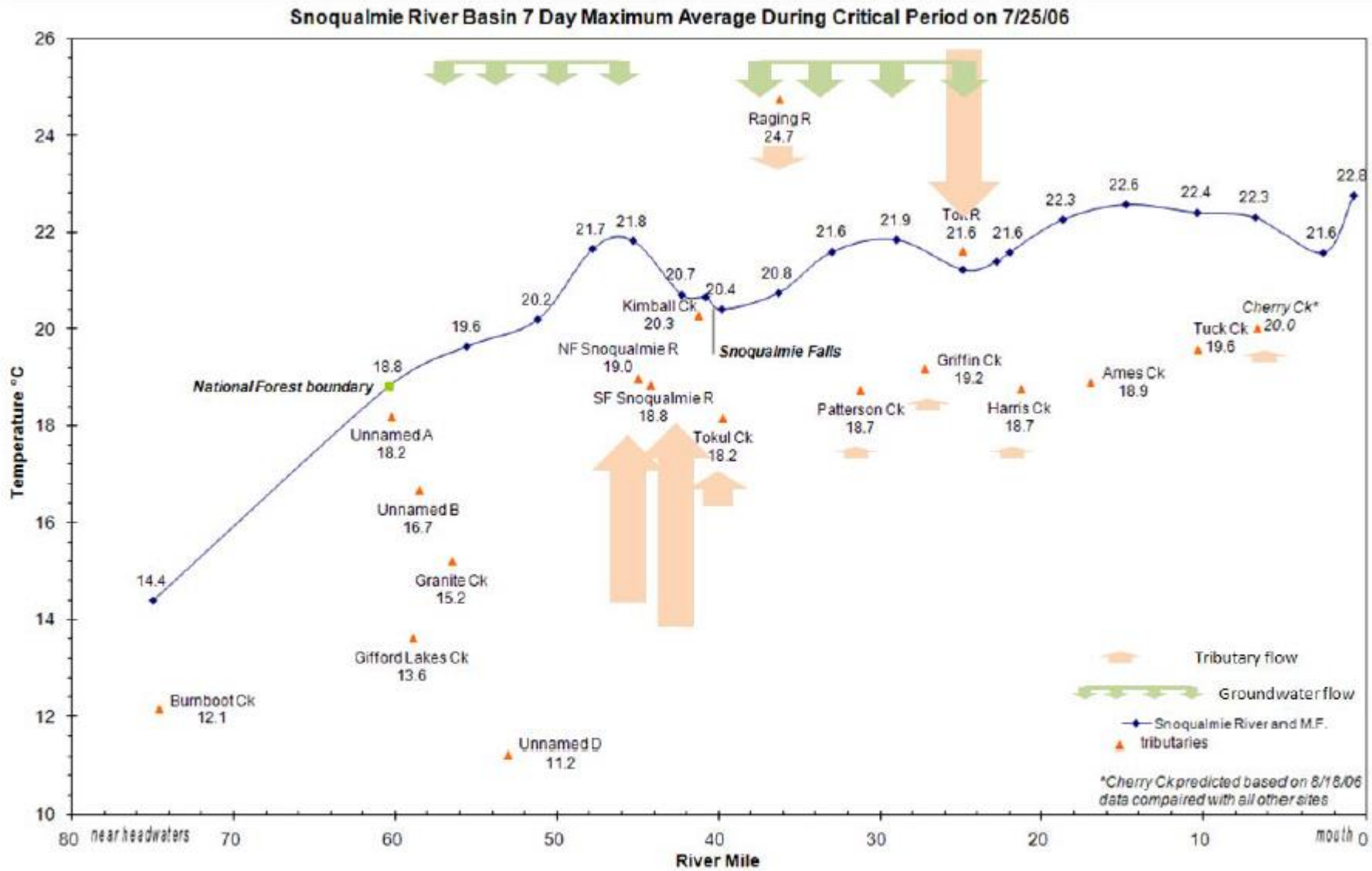


Figure 9. Snoqualmie River longitudinal profile 7-DADMax during the 2006 critical period, July 22 to 28, 2006.

From: 2011 TMDL (ECY)

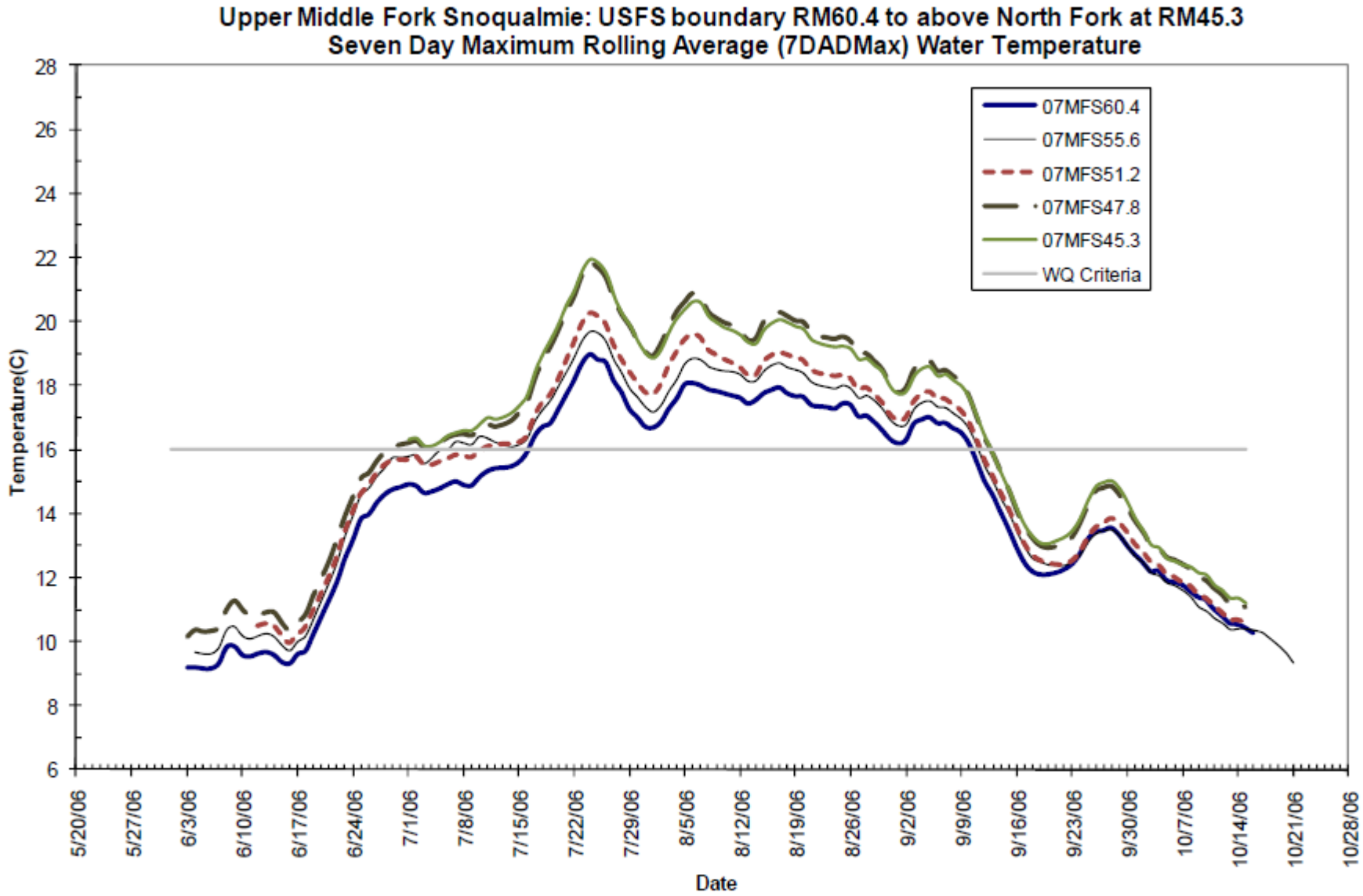


Figure 10. 7-Day average of daily maximum water temperatures in the Middle Fork Snoqualmie River from June to October 2006.

From: 2011 TMDL (ECY)

Hot Water and Low Flow: The Summer of 2015 in the Snoqualmie River Watershed

Photo by Jason Walker

May 2016

Department of Natural Resources and Parks
Water and Land Resources Division
Science and Technical Section
King Street Center, KSC-NR-0600
Seattle, WA 98104
204-477-4800 TTY Relay: 711
www.kingcounty.gov

Figure 32. Mainstem Snoqualmie 7DADMAX range and WA Ecology thresholds for designated uses. State Standards after Sept. 15 specific for spawning and egg Incubation.

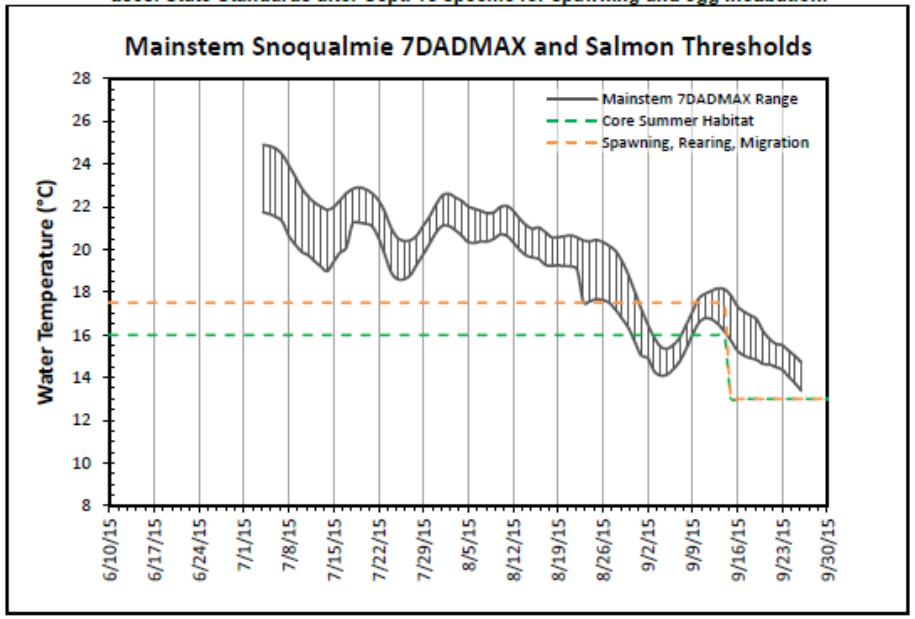


Figure 33. Mainstem Snoqualmie 1DMAX range and WA Ecology thresholds for barrier to migration and acute lethality.

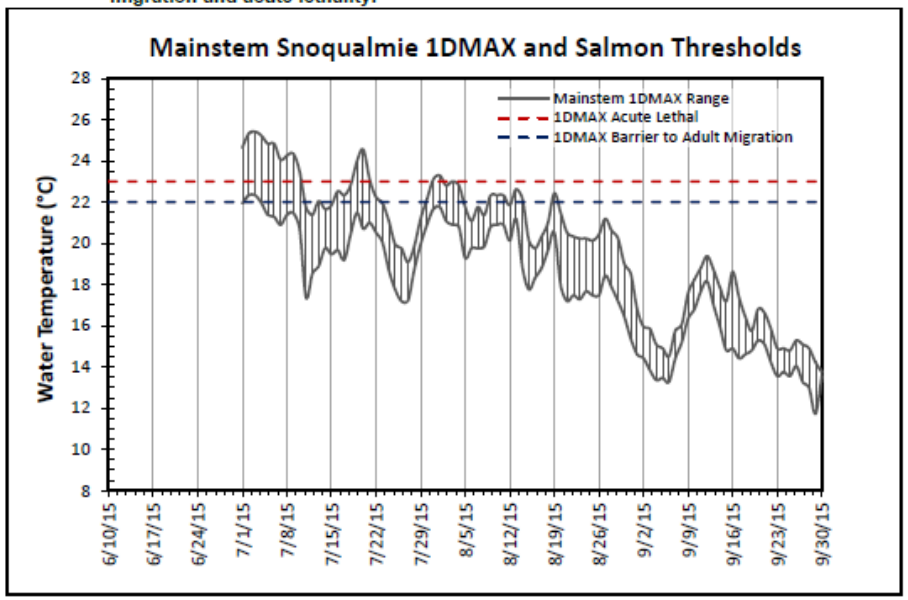
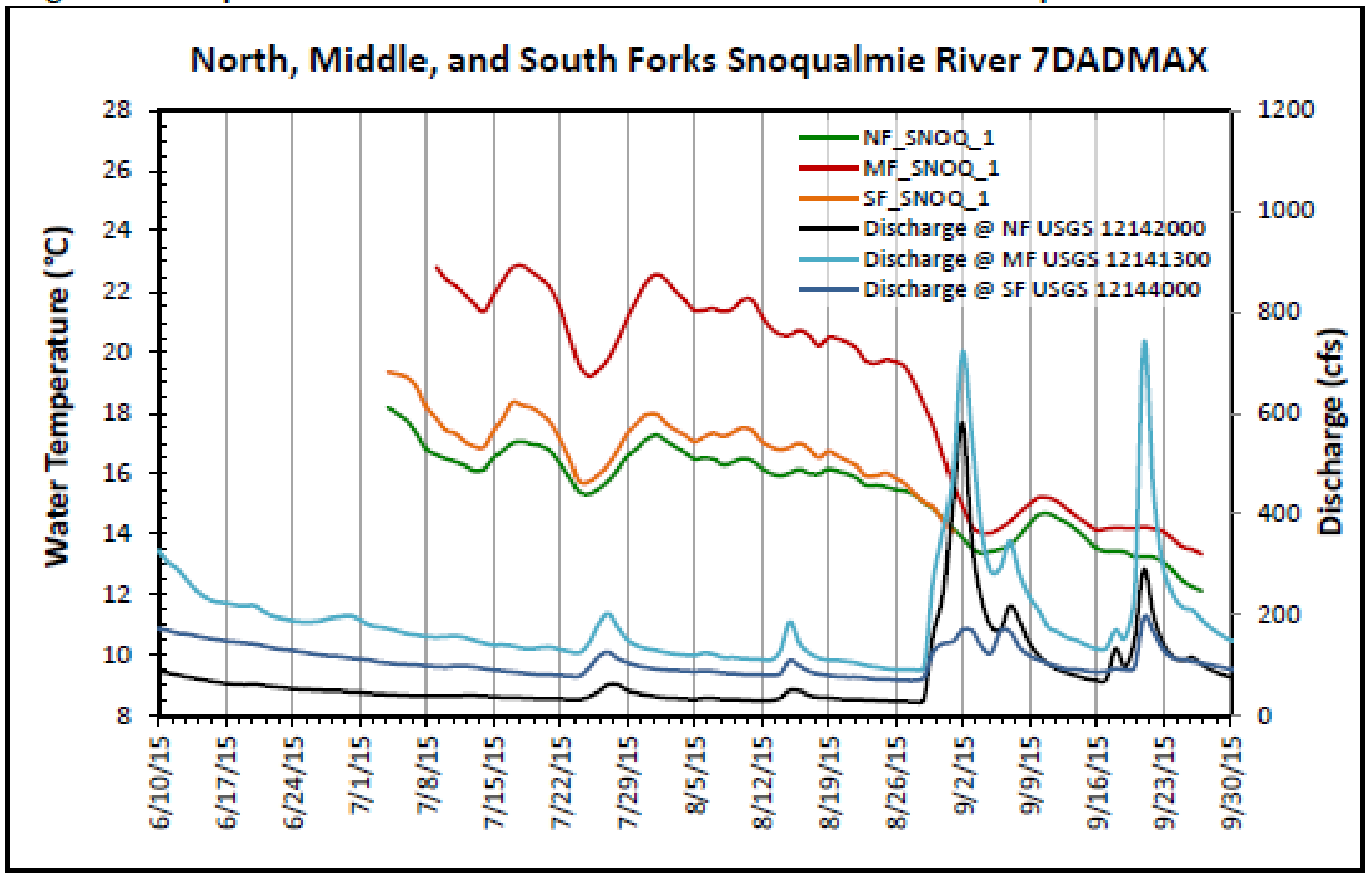


Figure 22. Temperature and flow time-series for the three forks of the Snoqualmie River.



"…the Middle Fork Snoqualmie contributed on average 50.5% (with up to 61.6%) of the flow coming out of all three of the forks." (p. 36)

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION

AMERICAN WATER RESOURCES ASSOCIATION

SPATIAL AND TEMPORAL VARIATION OF WATER TEMPERATURE REGIMES ON THE SNOQUALMIE RIVER NETWORK[1]

E. Ashley Steel, Colin Sowder, and Erin E. Peterson[2]

ABSTRACT: Although mean temperatures change annually and are highly correlated with elevation, the entire thermal regime on the Snoqualmie River, Washington, USA does not simply shift with elevation or season. Particular facets of the thermal regime have unique spatial patterns on the river network and at particular times of the year. We used a spatially and temporally dense temperature dataset to generate 13 temperature metrics representing popular summary measures (e.g., minimum, mean, or maximum temperature) and wavelet variances over each of seven time windows. Spatial stream-network models which account for within-network dependence were fit using three commonly used predictors of riverine thermal regime (elevation, mean annual discharge, and percent commercial area) to each temperature metric in each time window. Predictors were strongly related ($r^2 > 0.6$) to common summaries of the thermal regime but were less effective at describing other facets of the thermal regime. Relationships shifted with season and across facets. Summer mean temperatures decreased strongly with increasing elevation but this relationship was weaker for winter mean temperatures and winter minimum temperatures; it was reversed for mean daily range and there was no relationship between elevation and wavelet variances. We provide examples of how enriched information about the spatial and temporal complexities of natural thermal regimes can improve management and monitoring of aquatic resources.

(KEY TERMS: river network; time series analysis; spatial modeling; thermal regime; wavelet decomposition; metric.)

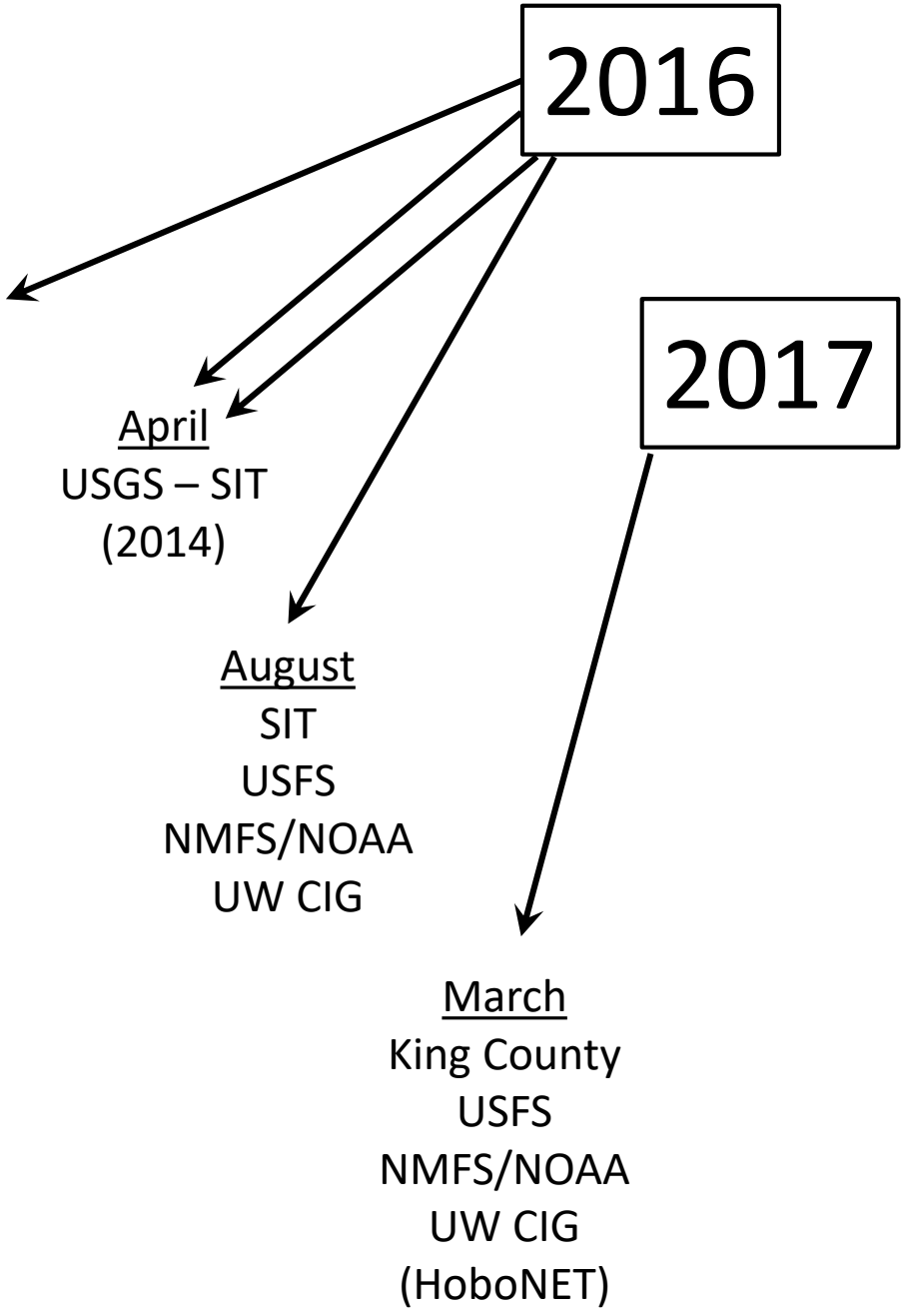
Steel, E. Ashley, Colin Sowder, and Erin E. Peterson, 2016. Spatial and Temporal Variation of Water Temperature Regimes on the Snoqualmie River Network. *Journal of the American Water Resources Association* (JAWRA) 1-19. DOI: 10.1111/1752-1688.12423

INTRODUCTION

Water temperatures fluctuate over time (Arismendi *et al.*, 2013) and along river networks (Fullerton *et al.*, 2015), playing critical roles as both drivers and indicators of riverine health. Conceptualizing a unique time series of water temperature data at every point on a river network is a challenge; measuring or modeling the full suite of spatially and temporally variable data across a river network is daunting. One year of river temperature data from a single sensor measured every hour yields over 8,700 observations. Instead of directly analyzing a time

[1]Paper No. JAWRA-15-0148-P of the *Journal of the American Water Resources Association* (JAWRA). Received September 3, 2015; accepted March 7, 2016. © 2016 American Water Resources Association. **Discussions are open until six months from issue publication.**

[2]Quantitative Ecologist and Supervisory Statistician (Steel), Pacific Northwest Research Station, USDA Forest Service, 400 North 34th Street, Suite 201, Seattle, Washington 98103; Research Assistant (Sowder), Department of Statistics, University of Washington, Seattle, Washington 98195; and (Formerly) Senior Research Scientist (Peterson), CSIRO Digital Productivity Flagship, Dutton Park, Queensland, 4102 Australia, (Currently) Principal Research Fellow (Peterson), ARC Centre for Excellence in Mathematics and Statistics and the Institute for Future Environments, Queensland University of Technology, Brisbane, Queensland, 4000 Australia (E-Mail/Steel: asteel@fs.fed.us).



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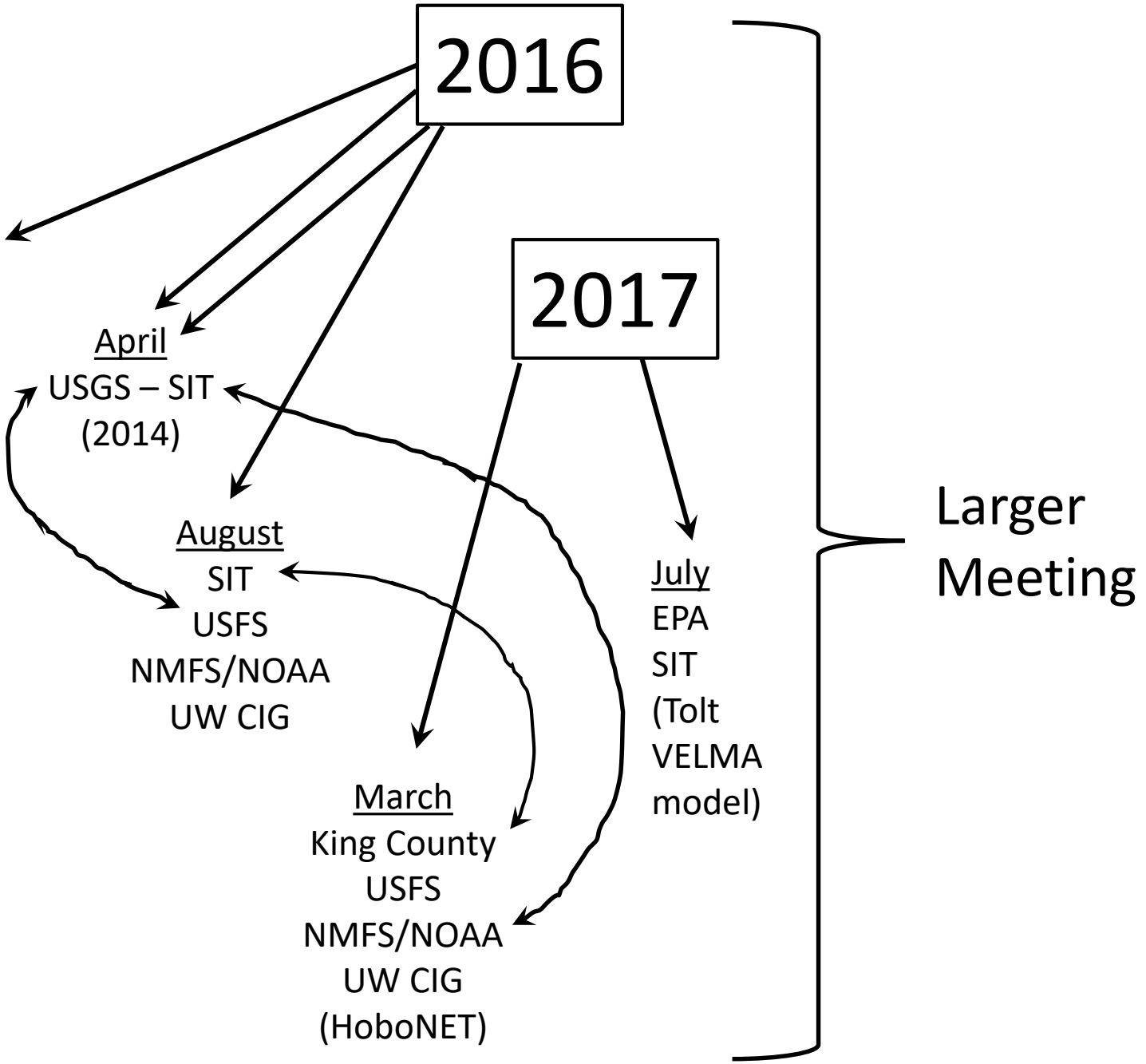
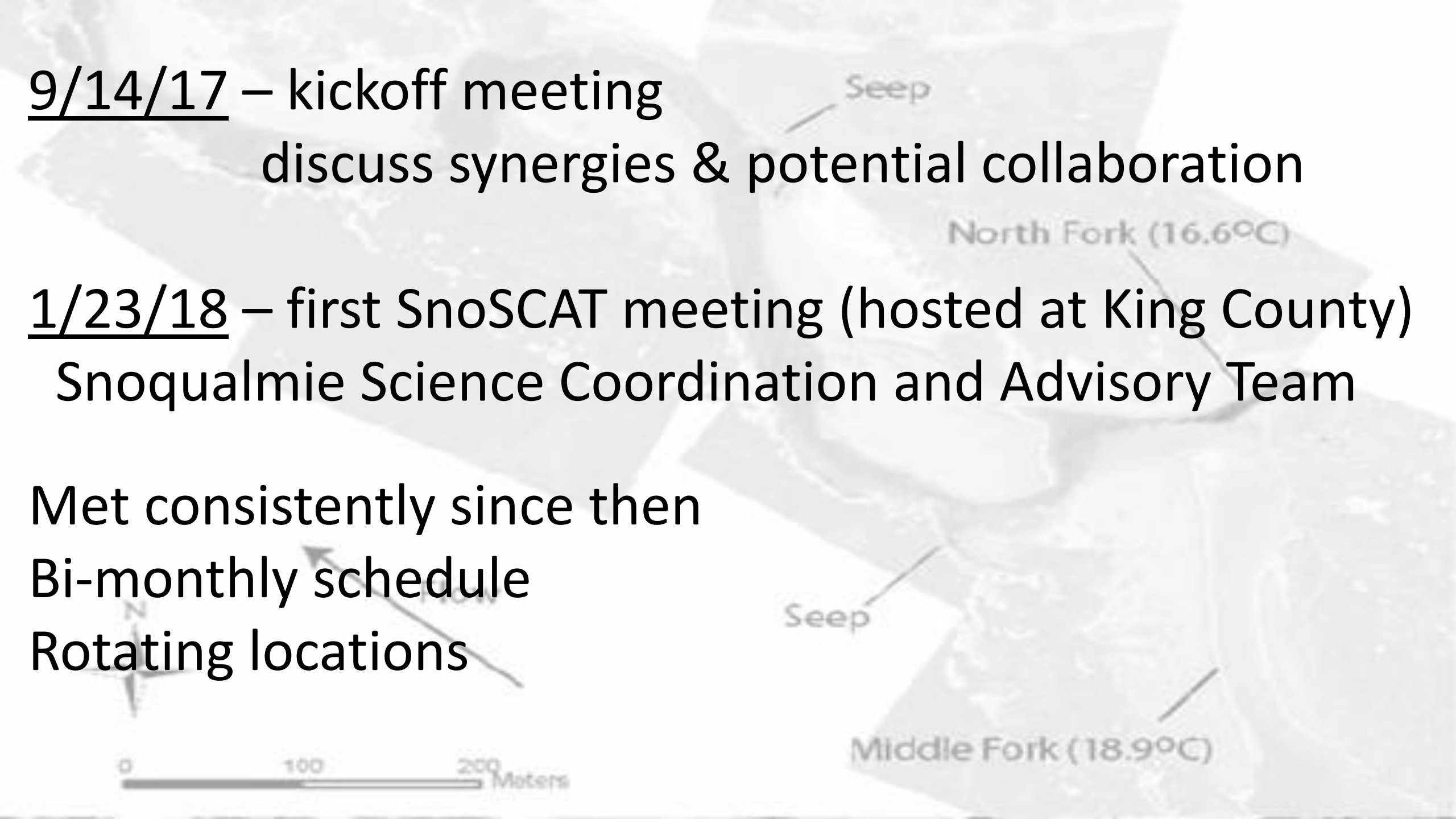


<u>9/14/17</u> – kickoff meeting
discuss synergies & potential collaboration

<u>1/23/18</u> – first SnoSCAT meeting (hosted at King County)
Snoqualmie Science Coordination and Advisory Team

Met consistently since then
Bi-monthly schedule
Rotating locations



Who comes to SnoSCAT?

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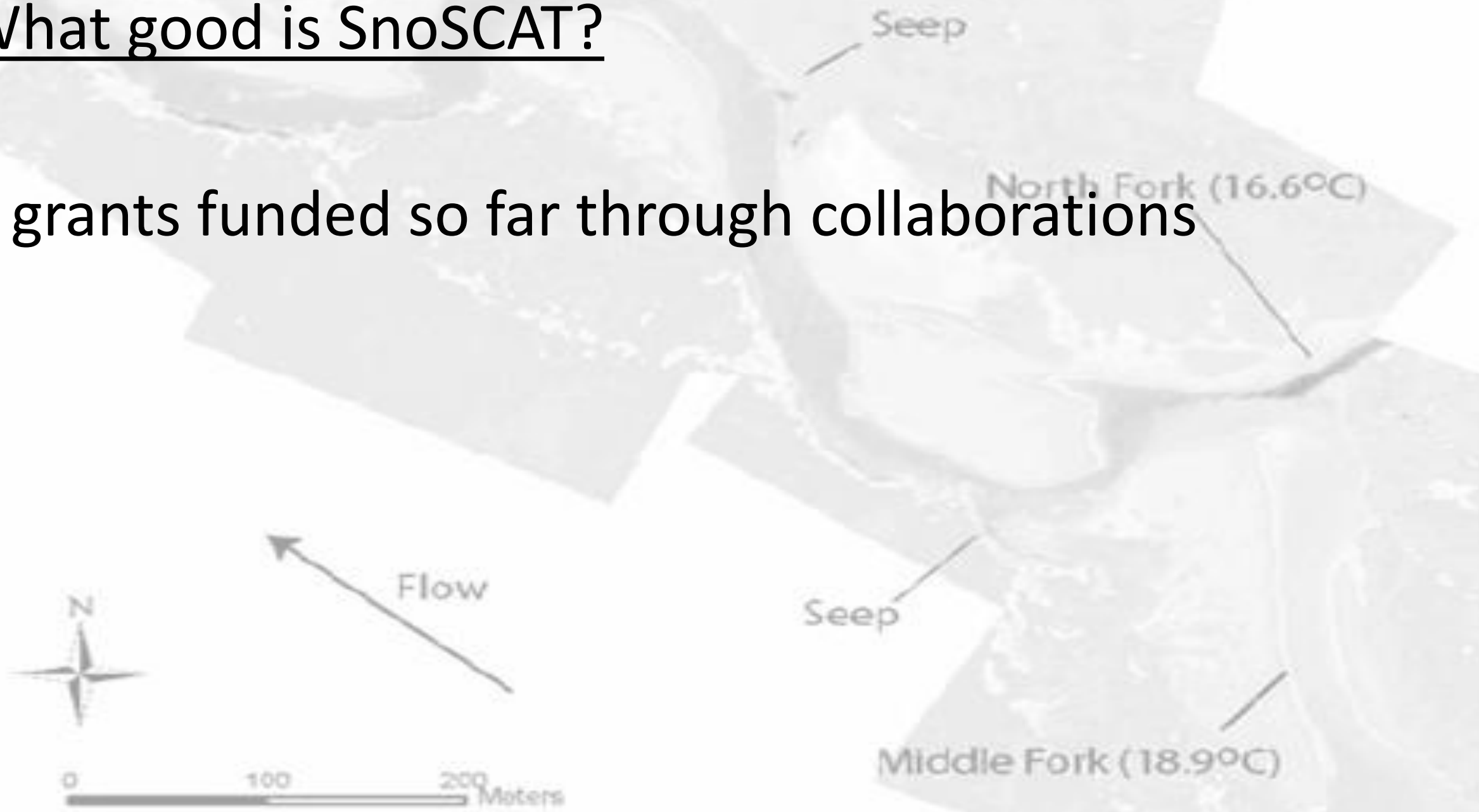
Sun, Ning, Pacific Northwest National Lab ning.sun@pnnl.gov
[Kubo, Josh, King County josh.kubo@kingcounty.gov]
[Nelson, Libby, Tulalip Tribes lnelson@tulaliptribes-nsn.gov]
[Perry Falcone, King County, perry.falcone@kingcounty.gov]

What good is SnoSCAT?

2 grants funded so far through collaborations



What good is SnoSCAT?

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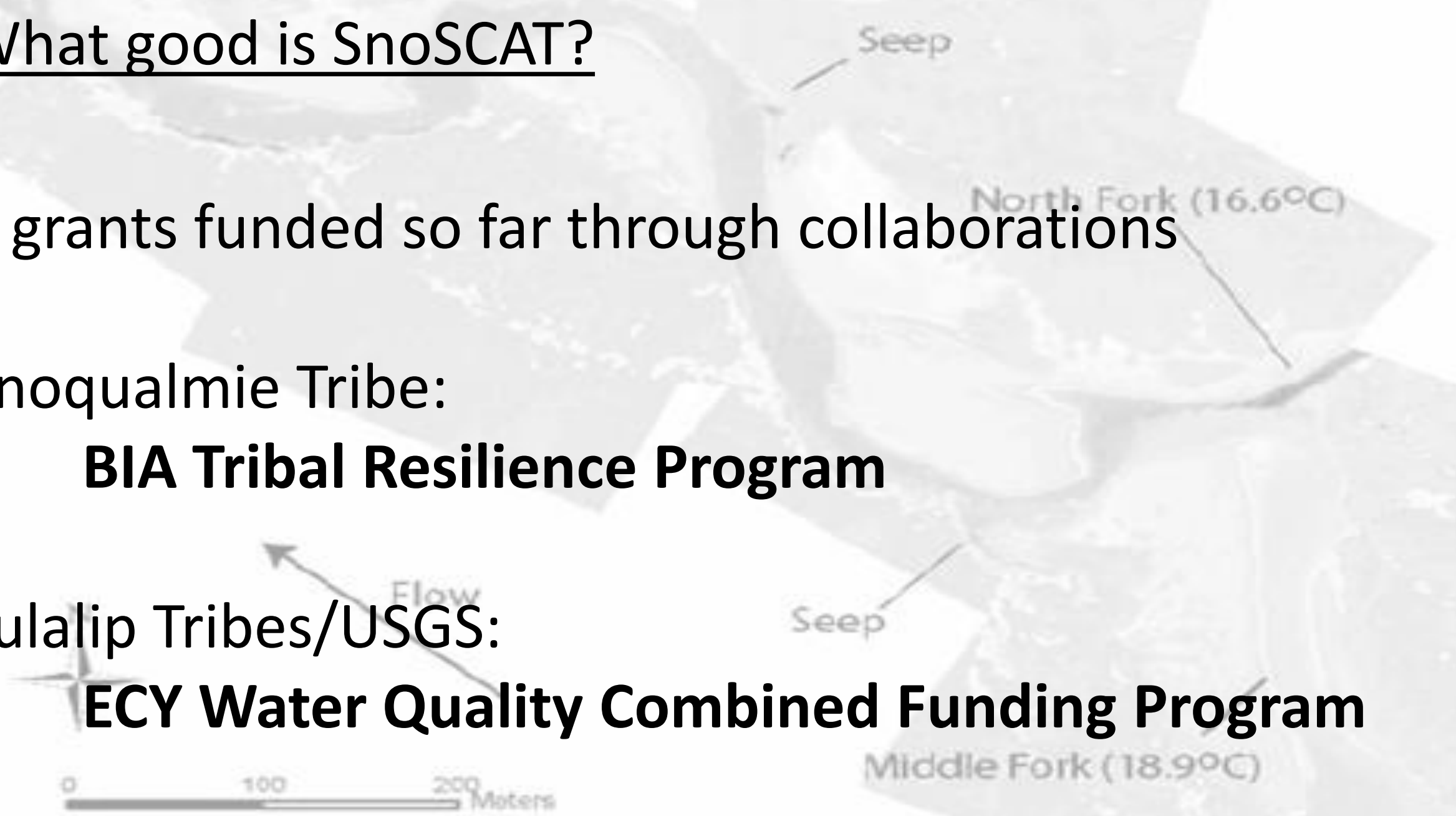
Snoqualmie Tribe:

BIA Tribal Resilience Program

Tulalip Tribes/USGS:

ECY Water Quality Combined Funding Program



Snoqualmie Tribe **BIA Tribal Resilience Program Grant**

The BIA Tribal Resilience Program (TRP) provides federal-wide resources to Tribes to build capacity and resilience through leadership engagement, delivery of data and tools, training and tribal capacity building.

Project Title: Assess future quantity and quality of coldwater habitat, and implications for native salmonid populations of the Snoqualmie River to support Snoqualmie Tribal resilience and adaptation planning.

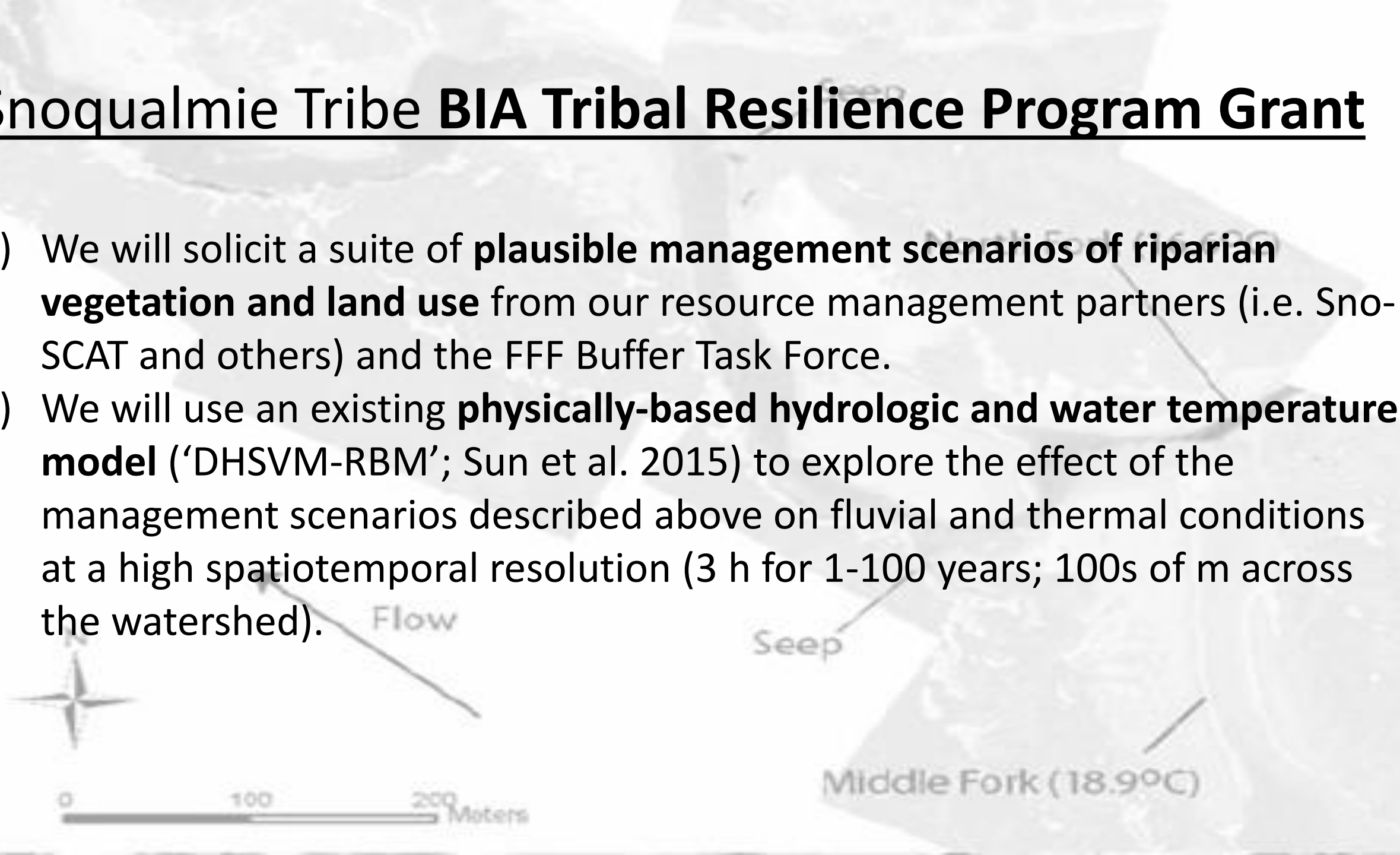
FY18 program award: **$149,256**

Snoqualmie Tribe **BIA Tribal Resilience Program Grant**

1) We will solicit a suite of **plausible management scenarios of riparian vegetation and land use** from our resource management partners (i.e. Sno-SCAT and others) and the FFF Buffer Task Force.

Snoqualmie Tribe **BIA Tribal Resilience Program Grant**

1) We will solicit a suite of **plausible management scenarios of riparian vegetation and land use** from our resource management partners (i.e. Sno-SCAT and others) and the FFF Buffer Task Force.
2) We will use an existing **physically-based hydrologic and water temperature model** ('DHSVM-RBM'; Sun et al. 2015) to explore the effect of the management scenarios described above on fluvial and thermal conditions at a high spatiotemporal resolution (3 h for 1-100 years; 100s of m across the watershed).



Snoqualmie Tribe **BIA Tribal Resilience Program Grant**

3) We will use an existing **individual-based model** (IBM; Fullerton et al. 2017) to estimate the response by salmonids to management, temperature, and precipitation scenarios.

Snoqualmie Tribe **BIA Tribal Resilience Program Grant**

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4) We will develop a workflow of guiding principles, hereafter **"guidance protocol,"** which can be used by practitioners who want to envision outcomes of management strategies to conserve diverse fluvial and thermal habitats needed to sustain viable fish populations alongside the needs of other water users. In addition to a generalized recipe, the guidance protocol will share practical lessons learned, and detail the aspects of models that need to be locally tailored.

Tulalip Tribes/USGS

ECY Water Quality Combined Funding Program

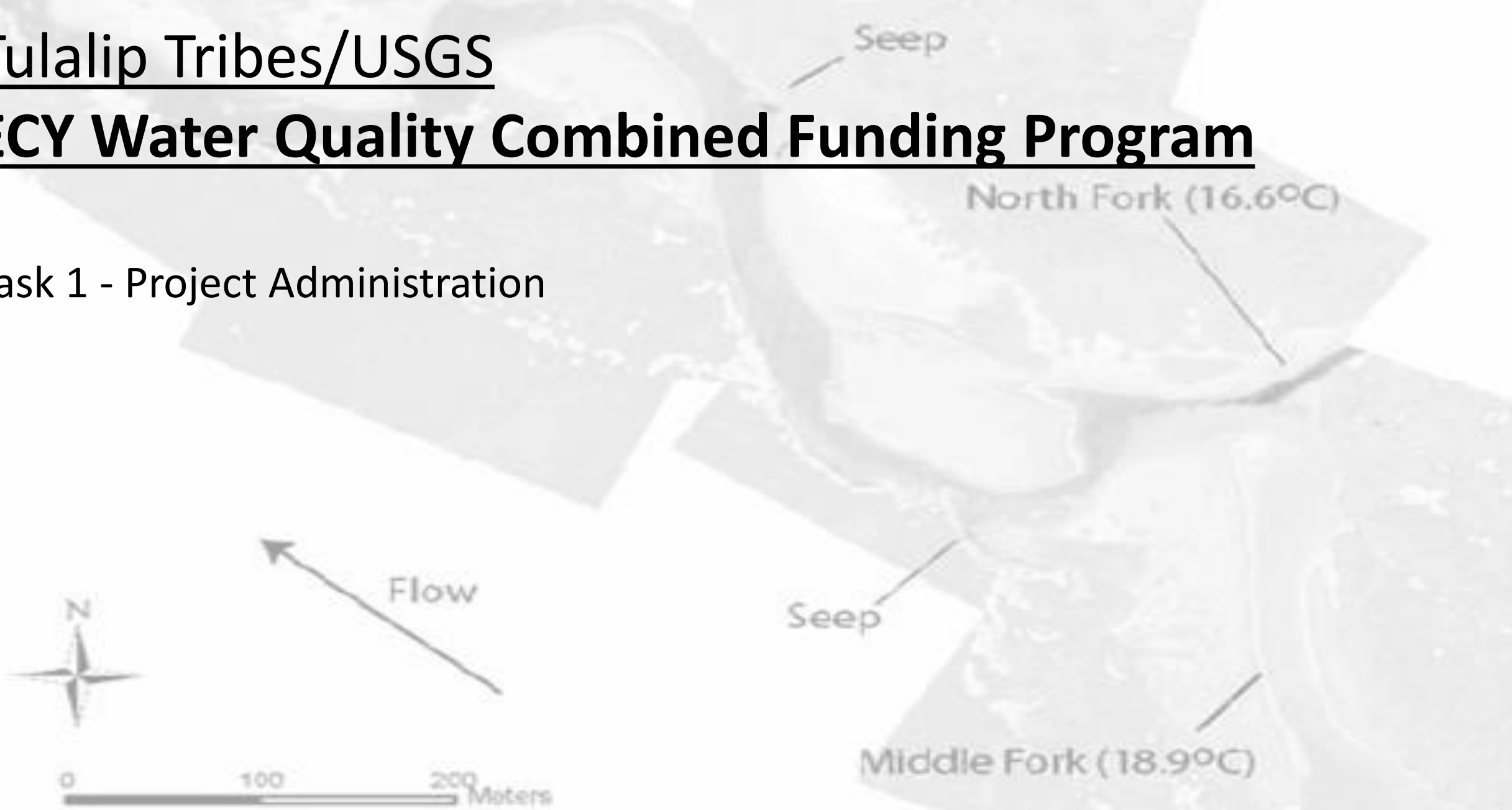
High Resolution Temperature Mapping

Award: $244,949
Match: $81,649

Tulalip Tribes/USGS

ECY Water Quality Combined Funding Program

Task 1 - Project Administration



Tulalip Tribes/USGS

ECY Water Quality Combined Funding Program

Task 1 - Project Administration – BORING!
Task 2 - Helicopter-based Thermal Infrared (TIR) Survey

The SC600 is a calibrated scientific grade long wave infrared camera with a sensitivity of 0.05 degrees C and an accuracy of +/- 2 degrees C or +/- 2% of the reading.

The goal of Task 2 is to quantify the spatial distribution of water surface temperatures in the Mainstem Snoqualmie River, Middle Fork Snoqualmie River and Lower Skykomish River using helicopter-based thermal infrared imagery.

Tulalip Tribes/USGS

ECY Water Quality Combined Funding Program

Task 1 - Project Administration
Task 2 - Helicopter-based Thermal Infrared (TIR) Survey
Task 3 - Longitudinal Drag-probe Temperature Survey

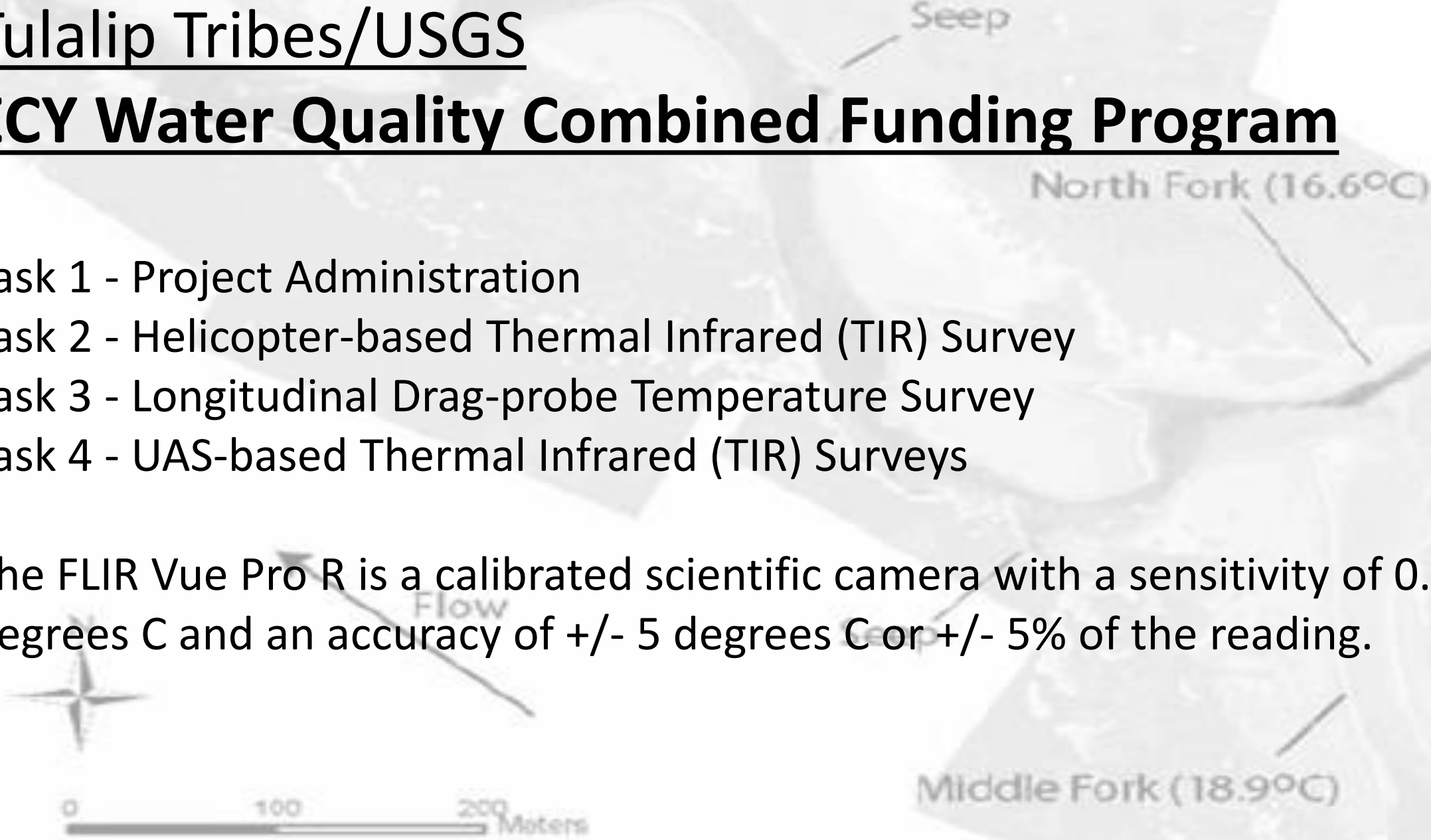
The goal of Task 3 is to quantify the spatial distribution of near-streambed and near-surface water temperatures in the Middle Fork Snoqualmie and Skykomish Rivers using a longitudinal “Lagrangian” drag-probe temperature survey.

Tulalip Tribes/USGS

ECY Water Quality Combined Funding Program

Task 1 - Project Administration
Task 2 - Helicopter-based Thermal Infrared (TIR) Survey
Task 3 - Longitudinal Drag-probe Temperature Survey
Task 4 - UAS-based Thermal Infrared (TIR) Surveys

The FLIR Vue Pro R is a calibrated scientific camera with a sensitivity of 0.1 degrees C and an accuracy of +/- 5 degrees C or +/- 5% of the reading.



Tulalip Tribes/USGS

ECY Water Quality Combined Funding Program

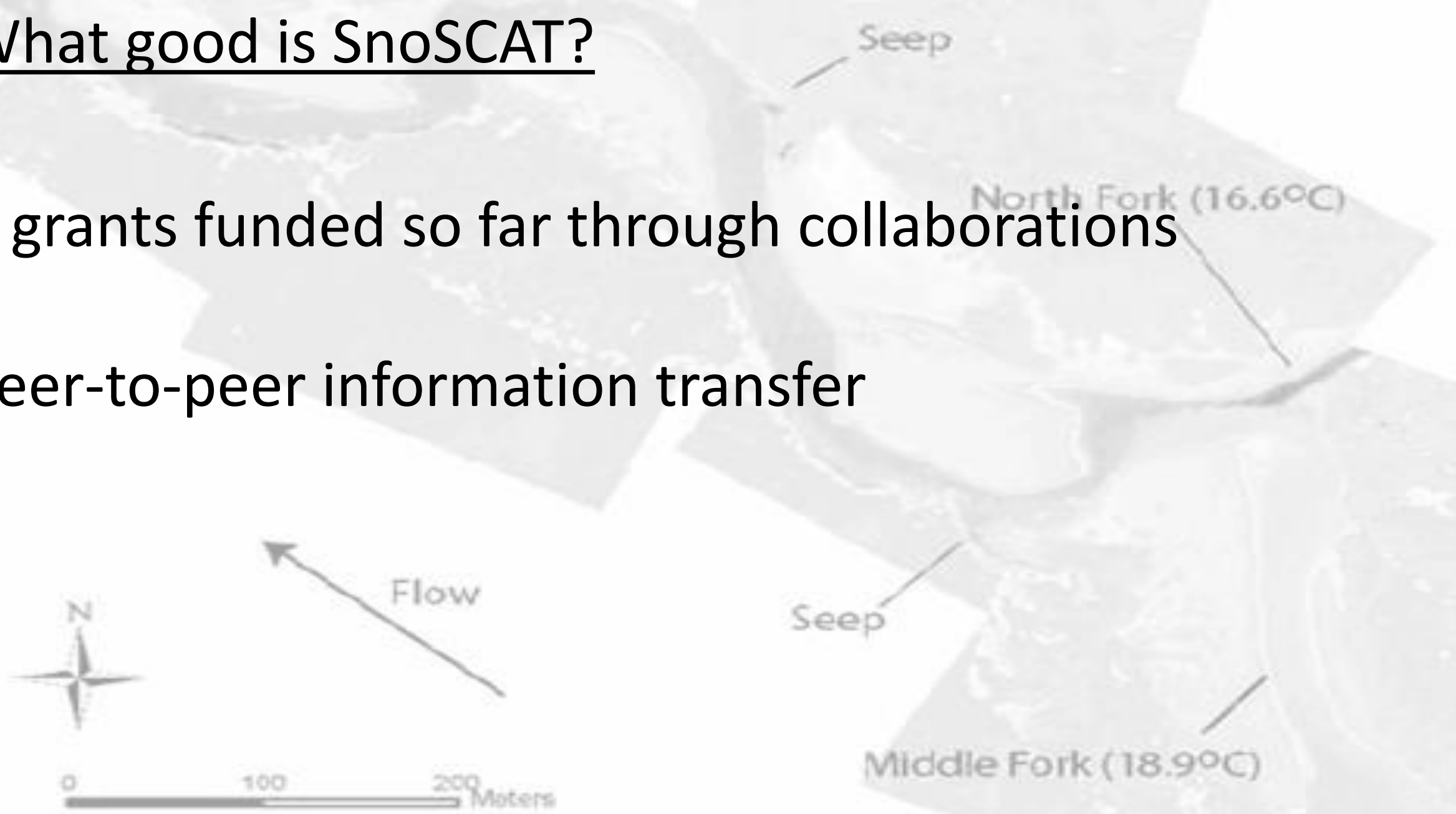
Task 1 - Project Administration
Task 2 - Helicopter-based Thermal Infrared (TIR) Survey
Task 3 - Longitudinal Drag-probe Temperature Survey
Task 4 - UAS-based Thermal Infrared (TIR) Surveys

The goal of Task 4 is to quantify the temporal and spatial distribution of water surface temperatures in the Mainstem Snoqualmie, Middle Fork Snoqualmie and Skykomish Rivers using UAS-based thermal infrared imagery, as well as **evaluate the relative ability of these methodologies in revealing groundwater seepage zones and other thermal influences in these river systems.**

What good is SnoSCAT?

2 grants funded so far through collaborations

Peer-to-peer information transfer



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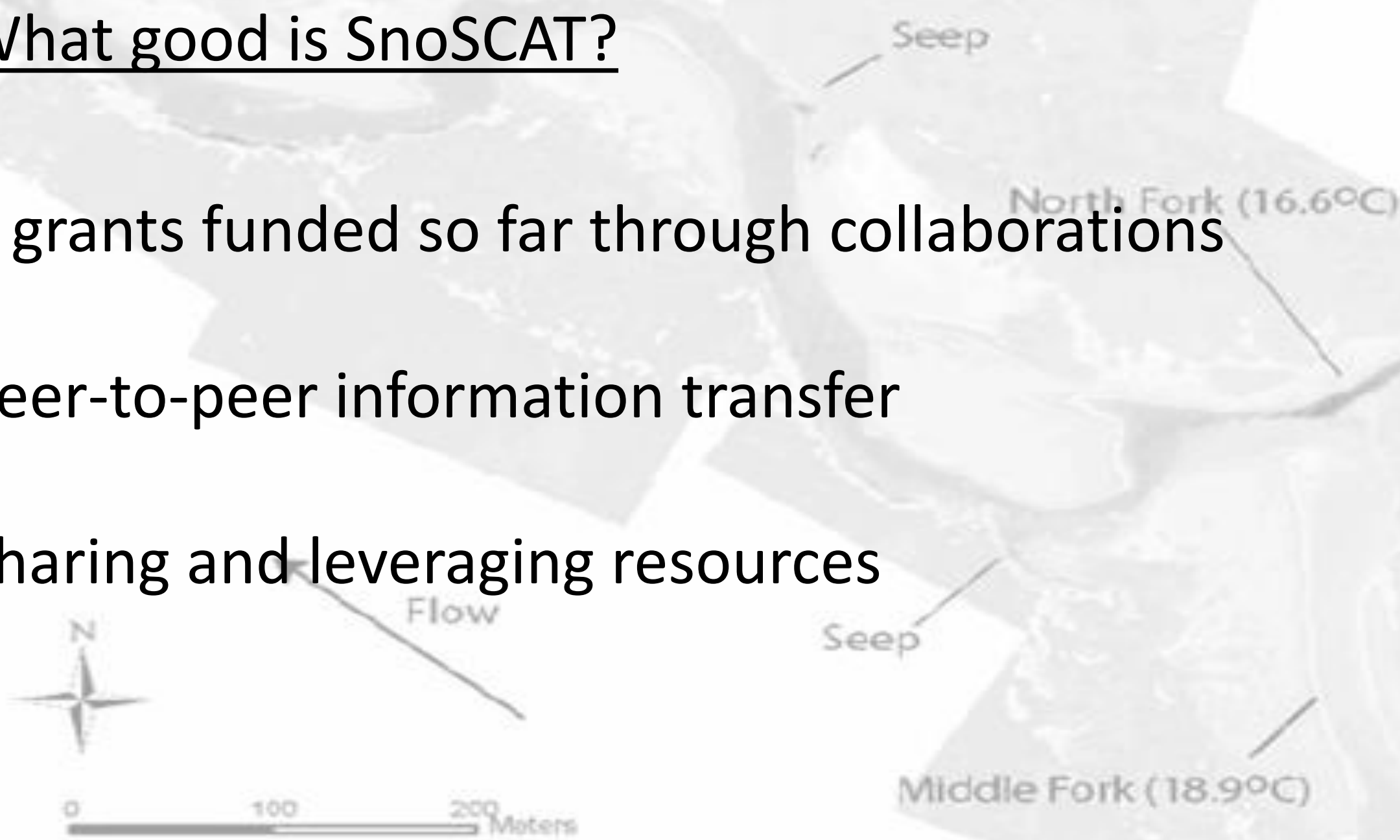
Peer-to-peer information transfer

Sharing and leveraging resources



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A collaborative roundtable focused on stream temperature in the Snoqualmie Watershed